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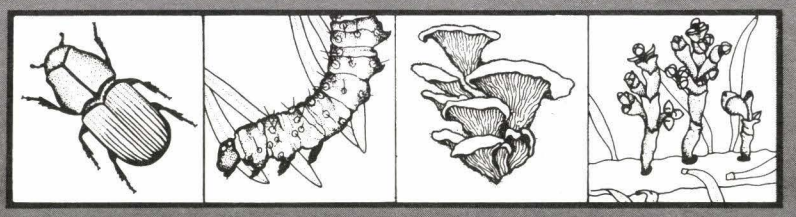

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APPLICATION OF PREDICTIVE MODEL TO FORECAST DOUGLAS-FIR TUSSOCK MOTH DEFOLIATION

by

Wayne E. Bousfield[1] and R. Ladd Livingston[2]

The Douglas-fir tussock moth[3] is a serious threat to western forests. In the past this defoliator has caused extensive damage to Douglas-fir and grand fir forests. Outbreaks are cyclic and occur about every 10 years in some areas.

During the 1972-75 tussock moth outbreak in the Northwest, a model to predict Douglas-fir tussock moth damage for northern Idaho was developed (Stoszek et al. 1981). This predictive defoliation model was derived from inventory data collected from 70 stands that covered several successional stages and site conditions that represent the variablity in the area. The purpose of the model is to provide a tool for the land manager to predict where and how serious tussock moth damage will be. The model will predict expected percent defoliation in a stand depending upon certain conditions. Variables in the model are (1) slope position, (2) depth of ash mantle (cm), (3) age of host trees, (4) basal area of stand (m^2/ha), (5) site index of Douglas-fir (m @ 50 years), and (6) percent of stand basal area that is grand fir. A description of the model and its coefficients is shown in Table 1.

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[1] Entomologist, Cooperative Forestry and Pest Management, R-1, Missoula, Mont.

[2] Entomologist, Idaho Dept. Lands, Coeur d'Alene, Idaho.

[3] Orgyia pseudotsugata (McDunnough)

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Table 1.--Predictive model for Douglas-fir tussock moth defoliation using basal area estimates (Stoszek et al. 1981).

Model: $\ln$ (% defoliation/host) $= b_0 + b_1 * SP = b_2 * AD + b_3 * \ln(HA) + b_4 * \ln(BA / SI) + b_5 * \ln(\%GF)$

Where:
SP = Slope position = 0 if lower slope
1 if upper slope
AD = Depth of ash mantel (cm)
HA = Host age at d.b.h. for stand
BA = Total stand basal area (m^2/ha)
SI = Douglas-fir site index (m @ 50 years)
%GF = Grand fir BA / total BA x 100

Parameter	Estimate	Standard deviation	Standardized coefficient	Variable index fit
b_0	-0.681	--	--	--
b_1	0.447	0.198	0.211	1.146
b_2	-0.012	0.005	-0.249	1.234
b_3	0.505	0.268	0.228	1.936
b_4	0.487	0.226	0.234	1.555
b_5	0.274	0.075	0.387	1.473

r^2 = 51.5% SEE = 0.734 = 32/5% of the mean
F = 13.60 p {F $\geq$ 13.60} < 0.0001

This paper describes the application of programmable calculators for using the model. Programmable calculators are efficient for the numerous calculations necessary in the model and for making the English to metric conversions. Programs have been developed for Hewlett Packard 65, 67, 97, and 41C, and for Texas Instruments 59 calculators. The damage model developed by Stoszek requires metric units for some of the variables; however, for the convenience of users, input for the programmable calculators is in English units and is converted to metric units internally.

Instructions for data entry for each calculator are provided, and an example of three stands is shown in Table 2. Before the calculators can be used they must be programmed by following the steps listed in Appendix 1 or by using a preprogrammed magnetic card. The HP-41C can recall the program from memory if the calculator has the program catalogued.

Table 2.--Instructions for HP-65, HP-67, HP-97, HP-41C, and TI-59 programmable calculators representing three different stand and site conditions.

Instructions for HP-65, HP-67, and HP-97

Stand 1 variable	Value	Key	Display
Slope position	(1)	A	1.0
Ash depth (inches)	(17)	A	17.0
Average host age	(160)	A	160.0
Stand basal area (ft^2/ac)	(172)	A	172.0
Grand fir basal area (ft^2/ac)	(103.2)	A	103.0
Douglas-fir site index (ft @ 50 yr)	(41)		

Predicted % defoliation = 32.9

Instructions for TI-59

Stand 2 variable	Value	Key	Display
Slope position	(0)	A	0
Ash depth (inches)	(15)	B	15
Average host age	(110)	C	110
Stand basal area (ft^2/ac)	(90)	D	90
Grand fir basal area (ft^2/ac)	(30)	E	30
Douglas-fir site index (ft @ 50 yrs)	(52)	2nd A	52

Predicted % defoliation = 10.2

Instructions for HP-41C

Stand 3 variable	Prompt	Value	Key
Slope position	(SLOPE POS.?)	(1)	R/S
Ash depth (inches	(ASH DPTH/IN/)	(18)	R/S
Average host age	(AVG. HOST AGE)	(150)	R/A
Stand basal area (ft^2/ac)	STAND BA ?)	(132)	R/A
Grand fir basal area (ft^2/ac)	GS BA ?)	(100)	R/S
Douglas-fir site index (ft @ 50 yr)	DF SITE ?)	(40)	R/S
	(DEF HAZ=)	(29.3)	

Appendix 1.--HP-65 program for rating Douglas-fir tussok moth stand susceptibility.

Step	Key	Step	Key	Step	Key	Step	Key
1	0.00	26	.	51	x	76	RCL 4
2	LBL	27	4	52	+	77	/
3	A	28	4	53	RCL 4	78	1
4	STO 1	29	7	54	4	79	0
5	R/S	30	x	55	.	80	0
6	LBL	31	RCL 2	56	3	81	x
7	A	32	2	57	3	82	f
8	STO 2	33	.	58	6	83	ln
9	R/S	34	5	59	/	84	.
10	LBL	35	4	60	RCL 6	85	2
11	A	36	x	61	.	86	7
12	STO 3	37	.	62	3	87	4
13	R/S	38	0	63	0	88	x
14	LBL	39	1	64	4	89	+
15	A	40	2	65	x	90	.
16	STO 4	41	CHS	66	/	91	6
17	R/S	42	x	67	f	92	8
18	LBL	43	+	68	ln	93	1
19	A	44	RCL 3	69	.	94	-
20	STO 5	45	f	70	4	95	f-1
21	R/S	46	ln	71	8	96	ln
22	LBL	47	.	72	7	97	RTN
23	A	48	5	73	x		
24	STO 6	49	0	74	+		
25	RCL 1	50	5	75	RCL 5		

Appendix 1, cont.--HP-67 or 97 program for rating Douglas-fir tussock moth stand susceptibility.

Step	Key	Step	Key	Step	Key	Step	Key
01	LBLA	26	.	51	/	76	7
02	STO1	27	5	52	RCL6	77	4
03	R/6	28	4	53	.	78	x
04	LBLA	29	x	54	3	79	+
05	STO2	30	.	55	0	80	.
06	R/S	31	0	56	4	81	6
07	LBLA	32	1	57	x	82	8
08	STO3	33	2	58	/	83	1
09	R/S	34	CHS	59	LN	84	-
10	LBLA	35	x	60	.	85	e^x
11	STO4	36	=	61	4	86	DSP
12	R/S	37	RCL4	62	8	87	1
13	LBLA	38	LN	63	7	88	RTN
14	STO5	39	.	64	x		
15	R/S	40	5	65	+		
16	LBLA	41	0	66	RCL5		
17	STO6	42	5	67	RCL4		
18	RCL1	43	X	68	/		
19	.	44	+	69	1		
20	4	45	RCL4	70	0		
21	4	46	4	71	0		
22	7	47	.	72	x		
23	x	48	3	73	LN		
24	RCL2	49	5	74	.		
25	2	50	6	75	2		

Appendix 1, cont.--HP-41C program for rating Douglas-fir tussock moth susceptibility.

Step	Key	Step	Key
01	LBL DFTM	29	RCL 02
02	FIX 1	30	4.356
03	-0.681	31	/
04	.447	32	DF SITE ?
05	SLOPE POS. ?	33	PROMPT
06	PROMPT	34	.304
07	*	35	*
08	+	36	/
09	-.012	37	LN
10	ASH DEPTH./IN/	38	.487
11	PROMPT	39	*
12	2.54	40	RCL 01
13	*	41	+
14	*	42	RCL 03
15	+	43	RCL 02
16	.505	44	/
17	AVE HOST AGE ?	45	100
18	PROMPT	46	*
19	LN	47	LN
20	*	48	.274
21	+	49	*
22	STO 01	50	+
23	STAND BA /	51	E|X
24	PROMPT	52	DEF HAZ=
25	STO 02	53	ARCL X
26	GF BA ?	54	AVIEW
27	PROMPT	55	END
28	STO 03		

Appendix 1, cont.--TI-59 program for rating Douglas-fir tussock moth stand susceptibility.

Step	Code	Key	Step	Code	Key	Step	Code	Key
000	76	LBL	041	93	.	082	54	)
001	11	A	042	05	5	083	54	)
002	42	STO	043	04	4	084	23	LNX
003	01	01	044	65	x	085	65	x
004	91	R/S	045	93	.	086	93	.
005	76	LBL	046	00	0	087	04	4
006	12	B	047	01	1	088	08	8
007	42	STO	048	02	2	089	07	7
008	02	02	049	54	)	090	85	+
009	91	R/S	050	85	+	091	53	(
010	76	LBL	051	53	(	092	53	(
011	13	C	052	43	RCL	093	43	RCL
012	42	STO	053	03	03	094	05	05
013	03	03	054	23	LXN	095	55	/
014	91	R/S	055	65	x	096	43	RCL
015	76	LBL	056	93	.	097	04	04
016	14	D	057	05	5	098	65	x
017	42	STO	058	00	0	099	01	1
018	04	04	059	05	5	100	00	0
019	91	R/S	060	54	)	101	00	0
020	76	LBL	061	85	+	102	54	)
021	15	E	062	53	(	103	23	LNX
022	42	STO	063	53	(	104	65	x
023	05	05	064	43	RCL	105	92	.
024	91	R/S	065	04	04	106	02	2
025	76	LBL	066	55	/	107	07	7
026	16	A	067	04	4	108	04	4
027	42	STO	068	93	.	109	54	)
028	06	06	069	03	3	110	75	-
029	93	.	070	05	5	111	93	.
030	04	4	071	06	6	112	06	6
031	04	4	072	54	)	113	08	8
032	07	7	073	55	/	114	01	1
033	65	x	074	53	(	115	95	=
034	43	RCL	075	43	RCL	116	22	INV
035	01	01	076	06	06	117	23	LNX
036	75	-	077	65	x	118	58	FIX
037	43	RCL	078	93	.	119	02	02
038	02	02	079	03	3	120	91	R/S
039	65	x	080	00	0			
040	02	2	081	04	4			

REFERENCES

Stoszek, Karel J., Peter G. Mika, James A. Moore, and Harold L. Osborne. 1981. Relationships of Douglas-fir tussock moth defoliation to site and stand characteristics in northern Idaho. Forest Sci. 27(3): 431-442.